AMENDMENTS TO THE CLAIMS

A detailed listing of all claims that are, or were, in the present application, irrespective of whether the claim(s) remains under examination in the application are presented below. The claims are presented in ascending order and each includes one status identifier. Those claims not cancelled or withdrawn but amended by the current amendment utilize the following notations for amendment: 1. deleted matter is shown by strikethrough for six or more characters and double brackets for five or less characters; and 2. added matter is shown by underlining.

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1. (Currently Amended) A unit fuel injector, the injector internally preparing fuel during an injection event at a pressure sufficient for injection into an internal combustion engine by means of an intensifier piston, comprising;

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a selectively actuatable controller being in fluid communication with a source of pressurized actuating fluid and being in fluid communication with a substantially ambient actuating fluid reservoir, the controller having a first valve responsive to a first electric actuator for selectively independently porting actuating fluid to and venting actuating fluid from the intensifier piston and a second valve responsive to a second electric actuator for selectively independently porting actuating fluid to and venting actuating fluid from a needle valve during the injection event for controlling opening and closing of the needle valve.

2. (Original) The unit fuel injector of claim 1 wherein the two valves are disposed in a coaxial arrangement.

3. (Original) The unit fuel injector of claim 2 wherein the two valves are independently electrically actuated.

4. (Original) The unit fuel injector of claim 3 wherein each of the two valves are independently solenoid operated in a first direction and spring operated in an opposed second direction.

5. (Original) The unit fuel injector of claim 1 wherein the second valve is operably fluidly coupled to a needle valve first closing surface.

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6. (Original) The unit fuel injector of claim 5 wherein actuating fluid ported by the second valve to the needle valve first closing surface generates a force acting to close the needle valve.

7. (Original) The unit fuel injector of claim 6 wherein the actuating fluid ported by the second valve to the needle valve first closing surface generates a force that is greater than an opposing force acting on a needle valve opening surface, the opposing force being generated by pressurized fuel.

8. (Original) The unit fuel injector of claim 5 wherein actuating fluid is being ported by the first valve to the intensifier piston, the actuating fluid ported by the second valve to the needle valve first closing surface acting to put the intensifier piston into a state of hydraulic lock.

9. (Original) The unit fuel injector of claim 8 wherein the second valve venting the actuating fluid ported to the needle valve first closing surface acts to free the intensifier piston from the state of hydraulic lock, the needle valve then being openable by the action of fuel pressurized by the intensifier piston acting on a needle valve opening surface.

10. (Original) The unit fuel injector of claim 5 wherein the second valve is cyclable between an open and a closed disposition a plurality of times during a single cycle of the first valve to effect a plurality of fuel injections and dwell periods during a single injection event.

11. (Original) The unit fuel injector of claim 5 wherein the second valve is shiftable to port actuating fluid to the needle valve first closing surface prior to shifting of the first valve to port actuating fluid to the intensifier piston, subsequent porting of the actuating fluid by the first valve to the intensifier piston acting to effect prebuilding fuel pressure.

12. (Original) The unit fuel injector of claim 1 further including a needle back piston being operably coupled to the needle valve.

13. (Original) The unit fuel injector of claim 12 wherein the needle back piston is in fluid communication with the second valve.

14. (Original) The unit fuel injector of claim 13 wherein the needle back piston is translatably disposed in a bore, the bore defining a portion of a variable displacement chamber, a

needle valve first closing surface of the needle back piston defining in part the variable displacement chamber.

15. (Original) The unit fuel injector of claim 14 wherein a return spring is disposed in the variable displacement chamber, the return spring exerting a bias on the needle valve first closing surface.

16. (Original) The unit fuel injector of claim 15 wherein the return spring bias on the needle valve first closing surface acts in cooperation with a fluid pressure on the needle valve first closing surface to generate a closing force on the needle valve.

17. (Original) The unit fuel injector of claim 16 wherein the needle valve first closing surface has an area exposable to actuating fluid that is sufficient for the generation of a closing force on the needle valve, the closing force exceeding an opposing needle valve opening force generated by high pressure fuel acting on the needle valve for a certain range of pressures of the actuating fluid.

18. (Original) The unit fuel injector of claim 12 wherein the needle back piston includes a shank, the shank bearing on a top margin of the needle valve.

19. (Original) The unit fuel injector of claim 18 wherein the top margin of the needle valve defines in part a chamber, the chamber being vented to a substantially ambient fuel return.

20. (Original) The unit fuel injector of claim 14 wherein the bore defines a portion of a second variable displacement chamber in cooperation with the needle back piston, the second variable displacement chamber being vented to the substantially ambient actuating fluid reservoir.

21. (Currently Amended) A method of injection control for a fuel injector, comprising;

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fluidly coupling a selectively actuatable controller with a source of pressurized actuating fluid and with a substantially ambient actuating fluid reservoir; and

controlling opening and closing of the needle valve by;

a. selectively independently porting actuating fluid to and venting actuating fluid from an intensifier piston by means of a first valve <u>by means of a first electric actuator</u>; and

b. selectively independently porting actuating fluid to and venting actuating fluid from a needle valve during an injection event by means of a second valve <u>by means of a second electric actuator</u>.

22. (Original) The method of claim 21 including disposing the two valves in a coaxial arrangement.

23. (Original) The method of claim 22 including independently electrically actuating the two valves.

24. (Original) The method of claim 22 including independently solenoid operating each of the two valves in a respective first direction and spring operating the two valves in a respective opposed second direction.

25. (Original) The method of claim 21 including operably fluidly coupling the second valve to a needle valve first closing surface.

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26. (Original) The method of claim 25 including generating a force acting to close the needle valve by porting actuating fluid by the second valve to the needle valve first closing surface.

27. (Original) The method of claim 26 generating a force by the second valve porting actuating fluid to the needle valve first closing surface, the force being greater than an opposing force acting on a needle valve opening surface by pressurized fuel.

28. (Original) The method of claim 27 including hydraulically locking the intensifier piston by the second valve porting actuating fluid to the needle valve first closing surface.

29. (Original) The method of claim 28 including unlocking the intensifier piston by the second valve venting the actuating fluid ported to the needle valve first closing surface and

subsequently opening the needle valve by action of fuel pressurized by the intensifier piston acting on a needle valve opening surface.

30. (Original) The method of claim 25 including effecting a plurality of fuel injections and dwell periods during a single injection event by cycling the second valve between an open and a closed disposition a plurality of times during a single cycle of the first valve.

31. (Original) The method of claim 25 including prebuilding fuel pressure by:

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shifting the second valve to port actuating fluid to the needle valve first closing surface;

subsequently shifting the first valve to port actuating fluid to the intensifier piston; and

subsequently venting the actuating fluid by the second valve.

32. (Original) The method of claim 25 including:

continually exposing a second needle valve closing surface to actuating fluid; and

generating a force on the second needle valve closing surface by pressurized actuating fluid effecting a needle valve valve opening pressure, the valve opening pressure being overcomable by a force of pressurized fuel acting on a needle valve opening surface.

33. (Original) The method of claim 32 including:

varying the needle valve valve opening pressure as a function of the pressure of the actuating fluid; and

varying the actuating fluid pressure at least as a function of an engine operating speed.

34. (Original) The method of claim 21 including the first valve porting actuating fluid to the intensifier piston a single time during an injection event.

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35. (Original) The method of claim 34 including the second valve porting actuating fluid to the needle valve to end injection prior to cessation of the first valve porting actuating fluid to the intensifier piston the single time during an injection event.

36. (Original) The method of claim 21 including effecting an injection control strategy during an injection event by selective porting of actuating by the second valve to the needle valve.

37. (Original) The method of claim 36 including slowly ramping up the rate of injection by the second valve venting the needle valve prior to the first valve porting actuating fluid to the intensifier piston.

38. (Original) The method of claim 36 including effecting a dwell in the rate of injection by the second valve porting actuating fluid to the needle valve and subsequently venting the needle valve while the first valve is porting actuating fluid to the intensifier piston.

39. (Original) The method of claim 36 including terminating injection by the second valve porting actuating fluid to the needle valve while the first valve is porting actuating fluid to the intensifier piston, the first valve subsequently venting the intensifier piston.

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40. (Original) The method of claim 36 including varying a valve opening pressure of the needle valve by varying the pressure of the actuating fluid ported by the first valve to the needle valve.

41. (Original) A hydraulically actuated, intensified fuel injector, comprising:

a controller achieving a desired injection control strategy by selectively independently porting actuating fluid to and venting actuating fluid from an intensifier piston to control the compressive stroke of the intensifier piston and selectively independently porting actuating fluid to and venting actuating fluid from a needle valve to control the opening and closing of the needle valve during the injection event.

42. (Original) The unit fuel injector of claim 41 wherein the controller includes a first and a second valve, the two valves being disposed in a coaxial arrangement.

43. (Original) The unit fuel injector of claim 42 wherein the two valves are independently electrically actuated.

44. (Original) The unit fuel injector of claim 43 wherein each of the two valves are independently solenoid operated in a first direction and spring operated in an opposed second direction.

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45. (Original) The unit fuel injector of claim 42 wherein the second valve is operably fluidly coupled to a needle valve first closing surface.

46. (Original) The unit fuel injector of claim 45 wherein actuating fluid ported by the second valve to the needle valve first closing surface generates a force acting to close the needle valve.

47. (Original) The unit fuel injector of claim 46 wherein the actuating fluid ported by the second valve to the needle valve first closing surface generates a force that is greater than an opposing force acting on a needle valve opening surface, the opposing force being generated by pressurized fuel.

48. (Original) The unit fuel injector of claim 45 wherein actuating fluid is being ported by the first valve to the intensifier piston, the actuating fluid ported by the second valve to the needle valve first closing surface acting to put the intensifier piston into a state of hydraulic lock.

49. (Original) The unit fuel injector of claim 48 wherein the second valve venting the actuating fluid ported to the needle valve first closing surface acts to free the intensifier piston from the state of hydraulic lock, the needle valve then being openable by the action of fuel pressurized by the intensifier piston acting on a needle valve opening surface.

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50. (Original) The unit fuel injector of claim 45 wherein the second valve is cyclable between an open and a closed disposition a plurality of times during a single cycle of the first valve to effect a plurality of fuel injections and dwell periods during a single injection event.

51. (Original) The unit fuel injector of claim 45 wherein the second valve is shiftable to port actuating fluid to the needle valve first closing surface prior to shifting of the first valve to port actuating fluid to the intensifier piston, subsequent porting of the actuating fluid by the first valve to the intensifier piston acting to effect prebuilding fuel pressure.

52. (Original) The unit fuel injector of claim 42 further including a needle back piston being operably coupled to the needle valve.

53. (Original) The unit fuel injector of claim 52 wherein the needle back piston is in fluid communication with the second valve.

54. (Original) The unit fuel injector of claim 53 wherein the needle back piston is translatably disposed in a bore, the bore defining a portion of a variable displacement chamber, a needle valve first closing surface of the needle back piston defining in part the variable displacement chamber.

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55. (Original) The unit fuel injector of claim 54 wherein a return spring is disposed in the variable displacement chamber, the return spring exerting a bias on the needle valve first closing surface.

56. (Original) The unit fuel injector of claim 55 wherein the return spring bias on the needle valve first closing surface acts in cooperation with a fluid pressure on the needle valve first closing surface to generate a closing force on the needle valve.

57. (Original) The unit fuel injector of claim 56 wherein the needle valve first closing surface has an area exposable to actuating fluid that is sufficient for the generation of a closing force on the needle valve, the closing force exceeding an opposing needle valve opening force generated by high pressure fuel acting on the needle valve for a certain range of pressures of the actuating fluid.

58. (Original) The unit fuel injector of claim 52 wherein the needle back piston includes a shank, the shank bearing on a top margin of the needle valve.

59. (Original) The unit fuel injector of claim 58 wherein the top margin of the needle valve defines in part a chamber, the chamber being vented to a substantially ambient fuel return..

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60. (Original) The unit fuel injector of claim 54 wherein the bore defines a portion of a second variable displacement chamber in cooperation with the needle back piston, the second variable displacement chamber being vented to the substantially ambient actuating fluid reservoir.

Claim Rejections

Claims 1-3, 5-8, 10, 12-18, 20, 41-43, 45-48, 50, 52-28 and 60 were rejected under 35 U.S.C. § 102(b) as being anticipated by Chen et al. (U.S. Pat. No. 5,682,858).

The present device, as noted at paragraph 22, provides for multiple cycles of the needle valve during an injection cycle while the spool valve that ports actuating fluid to the intensifier is cycled only once during an injection cycle such that the intensifier piston maintains a compressing stroke at all times during the injection cycle. This is direct needle valve control. Chen expressly teaches away from this, as noted at col. 1, lines 51-59, where Chen details a problem to be overcome by the Chen device. Chen states "With this (prior art) innovation of a direct control needle valve came a new problem... In particular, since the needle valve can close while the piston/plunger are in their downward (compressive) stroke and fuel is above valve opening pressure, pressure spikes can be generated..." The parenthetical material is added. The present invention provides direct control needle valve while the piston/plunger are in their downward (compressive) stroke.

Further, there is only a single electric actuation in the Chen device, that of the solenoid 30. The opening of the needle valve is controlled by solenoid 30. See col. 4, lines 10-12. The compressive stroke if the intensifier is also controlled by the solenoid 30. See col. 3. line 64 to col. 4, line 9. All controls of the injector of Chen are effected by energizing or de-energizing solenoid 30. In contrast, independent claims 1 and 21 have been amended to include the limitation of a first and a second electric actuator. In view of this, it is requested that this rejection be withdrawn.

Claim 41 recites "independently porting actuating fluid to and venting actuating fluid from an intensifier piston to control the compressive stroke of the intensifier piston and selectively independently porting actuating fluid to and venting actuating fluid from a needle valve to control the opening and closing of the needle valve during the injection event." There is

no independent control of the intensifier and the needle valve of Chen. As noted above, it is an object of Chen to avoid such control, which Chen views as problematic. Chen provides for split injection (See col. 6, lines 23-45) by de-energizing the solenoid 30. This closes the needle valve, but at the same time effectively halts the compressive stroke of the intensifier. The two actions are related to the de-energizing of the solenoid 30 and are definitely not independent. In view of this, it is requested that this rejection be withdrawn.

Claims 21-23, 25-28, 30-34, 36 and 40 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Chen et al. (U.S. Pat. No. 5,682,858).

Claim 21 has been amended to recite structural limitations not found in Chen as noted above. It is therefore requested that the rejection be withdrawn.

Allowable Subject Matter

Claims 4, 9, 11, 19, 24, 29, 35, 37-39, 44, 49, 51 and 59 were objected to as being dependent upon a rejected base claim, but were indicated allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.